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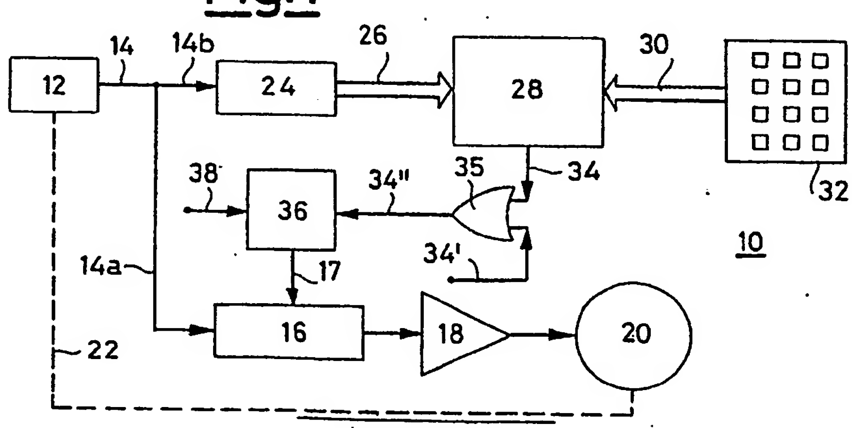
(54) System and device for having desired liquid volumes supplied by a metering pump in variable flow rate condition.

(57) In a metering vibrating pump in variable flow rate condition a system and a device for having desired liquid quantities supplied comprising a memory circuit (36) set a supply beginning signal (38), a counter (24) counting a certain pump stroke number detected by a detector (12) of piston position in said pump, a numerical comparator (28) comparing the numbers emitted by the counter (24) with preset numbers formed by a numerical combinator (32) for outputting a reset signal for said memory circuit (36), said memory circuit (36) starting the pumping operation when it is set and stopping said operation when it is reset.

Fig.1



System and device for having desired liquid volumes supplied by a metering pump in variable flow rate condition.

The present invention concerns a control device for having desired liquid volumes supplied by a metering pump even if, owing to external reasons, the flow rate of the pump would be variable.

In many industrial processes connected with automatic processing or packaging, such as automatic filling of containers or cans, as well as in many manual or automatic machines for distributing beverages and specifically warm beverages such as coffee percolators and automatic machines for preparing and distributing said warm beverages, there is the problem of supplying desired liquid volumes which not always can be equal to each other but must be selected every time in a simple and immediate way.

A very simple and primitive but rather precise, method for supplying desired liquid volumes, would be to fill in with said liquid a number of containers having known capacity and then to draw said liquid from said containers in order to have them completely emptied. Said method has the drawback of requiring a certain number of containers, having calibrated volume which, when in the case of a wide metering range may be untollerably high, adding encumbrance drawbacks and reducing the metering accuracy because of long connecting ducts introducing hardly evaluable and controllable supplementary capacities. This drawback can be partially done away with by using , just one graduated container (such as a graduated glass) allowing as many different capacities and the number of graduations on the container. This solution is however less precise in the metering because of unavoidable unaccuracies in calibrating the graduated container and in detecting the liquid level in said container. A more practical method, fully independent from calibrated containers, would be that of using a positive displacement pump such as , for example a piston pump, having constant stroke length and powered by a motor through a crank and link assembly, calibrated so as to stop after preset stroke number, estimated for example by counting, the number of revolutions done by the motor. Such a method can produce rater accurate meterings, but use of an expensive device such as the positive displacement pump and the problem of carefully stopping the pump at the expected time, adding rather high costs, can lead to such an expensive device which can not be installed in all apparatus, because not always the expense of such a solution is bearable.

A third method is to use piston pumps of the vibrating type comprising an electromagnet provided with a movable core rigidly connected to a piston movable within a cylinder whereby for any displacement of the movable core a like displacement of the piston corresponds.

In such a kind of pump, in order to cause an alternative displacement of the .piston, the coil winding of the electromagnet can be supplied with an alternating current or better with an unidirectional pulsating current, such as that obtained by rectifying just halfwave of a usual a.c. electric current. It is to be pointed out that when a current pulse is applied to the electromagnet of the above mentioned vibrating pump, the movable core is attracted within the electromagnet, causing a suction stroke of the piston and compressing a spring which is thus loaded during the suction stroke and is released when the current through said electromagnet is switched off giving place to a compression stroke. Thus, if the pump operates under unchanging conditions, i.e. having to overcome always the same resistance due to the backpressure , frictions, dilatations, wears, etc.., its stroke remains constant and every pump stroke provides a constant liquid flow rate.

Under so ideal conditions, being the liquid flow constant for every pump stroke, in order to obtain a desired liquid volume, it is sufficient to calculate the corresponding number of pump strokes and thus the number of current pulses applied to the electromagnet from the desired volume divided by the volume delivered by a single pump stroke;

As a consequence, in order to have a desired liquid volume delivered it is sufficient to apply a corresponding number of current pulses to the pump electromagnet. For counting the number of current pulses applied to the pump electromagnet it is sufficient to derivate from the voltage across said electromagnet coil, pulse signals to be counted by a digital counter starting with the first pulse received when a voltage begins to be applied to said electromagnet and, stopping after having counted a pulse number corresponding to the desired volume, core being also taken to stop the voltage application to the electromagnet, whereby the pump does effect just the desired stroke number to obtain the desired liquid volume. This system, by which pulses are generated from the network alternating current at the fixed frequence thereof, is basically objectionable owing to the resistances, to be overcome by the pump, which affect its stroke and thus the volume delivered by each single pump stroke. Specifically if the backpressure to be overcome by the pump varies, the flow rate thereof does also vary, and decreases when said backpressure increases. The main re-

lated drawback is that, the pump stroke number being the same different liquid volumes are delivered depending on the backpressure to be overcome and thus not only the liquid volume delivered by given pump stroke number can vary depending on the application, but it can also vary for the same application if the pump must inject a liquid in a pressurized vessel overcoming an increasing backpressure or anyhow variable resistances due to variable flow rate adjustment must be overcome, so that even for the same application the simple counting of the current pulses applied to an electromagnet can be no longer reliable.

As above mentioned the pump stroke variation as caused from the resistances to be overcome, originates from the fact that the vibrating pump comprises a piston moved by a movable core electromagnet withdrawing said core when the electromagnet is energized by a current, providing a suction stroke of the piston, and releasing it under the action of a spring loaded during the withdrawing motion, when the current through the electromagnet is switched off; if said pumps are supplied with current pulses having fixed repetition frequency, it may occur that, in case rather high resistences must be overcome, as for backpressure increases, the compression stroke of the pump is not ended before the arrival of next current pulse and, as a suction stroke begins before the end of the preceeding compression stroke, the length of the latter compression stroke is reduced and the volume delivered by the same number of pump strokes is correspondingly reduced.

In order to obviate such a serious problem, it has been suggested to fed the pump with current pulses having variably frequency, the beginning of which is controlled by a specific position of the piston within the cylinder so that a suction stroke always begins when the preceeding compression stroke is completely ended, thus enssuring a compression stroke having constant length and thus a constant flow rate of said pump an equal pump stroke number corresponds to an equal volume of delivered liquid.

A pump according to the above mentioned feature is described in the Italian utility model application No. 21796 B/84 having the same inventor of present application and filed on May 15, 1984. In said application there is described a vibrating pump provided with a detector of piston position which is energized by the piston taking a determined position within the pump cylinder or body, allowing the application of a current pulse to the pump electromagnet only when the piston reaches said position, said detector controlling a driving circuit for said electromagnet and sending also a pulse signal to a digital counter whose counting is increased by one unit every time the piston reaches said position in the pump casing. The counter emits a stopping pulse to the driving circuit, which had been started by a starting control, when a desired counting corresponding to the volume to be delivered by the pump is reached.

The pump of the above mentioned utility model application is rather satisfactory as a metering pump in variable flow rate condition, leading to rather precise metering, specifically in the field of the beverage automatic distributing machines and particularly in the field of the coffee preparing machines. However, as the main drawback it does allow just one desired metered liquid volume to be delivered unless a plurality of counters is adapted emitting a stopping signal for the electromagnet at the end of different countings corresponding to different metered volumes.

The present invention remedies the above mentioned drawback by using a vibrating pump comprising a piston actuated by a movable core moved by an electromagnet, a position detector for said piston, an enabling gate, between said piston position detector and a power amplifier driving said electromagnet, a device characterized by a memory circuit set by an energizing beginning control signal through said enabling gate, a counter counting pulses coming from said piston position detector and a numerical comparator circuit by which numbers in digital formate, coming from said counter, are compared with numbers coming from a digital combinator or numerator, providing a number corresponding to desired meterings, said numerical comparator circuit emitting a reset signal for said memory circuit in order to stop the energization of said electromagnet when the number appearing at the output of the counter coincides with the number appearing at the output of the digital combinator or numerator, said above memory further comprising a supplementary deenergization input to stop at will the energization for said electromagnet.

In a preferred embodiment, said digital combinator or numerator device is keyboard device similar to the devices used for digital remote controls or phone numerical dialting combinators.

According to a further embodiment of present invention in said vibrating pump having said memory set by selected one of a plurality of electromagnet energization starting controls, there is used a plurality of numerical comparator devices receiving:

a) in common the output of said digital counter,

b) the output of said digital numerating device, comprising a first digital address signal for one of said numerical comparator devices and a second digital signal corresponding to desired metering volumes;

c) an actuating signal associated with one of said controls for the setting of said memory and for the energization beginning for the electromagnet,

d) a deenergization signal associated with said memory resetting, anyone of said numerical comparators emitting a resetting signal for said memory circuit in order to stop the electromagnet energization, when the number appearing at the counter output coincides with the number at the output of the digital combinator or numerator device, coupled to the numerical comparator actuated by said preselected energization starting control and further comprising a further resetting input for the memory to arbitrarily disable said enabling gate in order to stop at will the energization of the electromagnet.

In a particular preferred embodiment of the present invention, a position detector of said piston is used having an hysteresis cycle broad enough to allow a safe and precise commutation between a high logical state and a low logical state of said position detector at certain piston positions.

In a further and more preferred embodiment of the present invention said piston position detector is a Hall effect magnetic detector.

In a further preferred embodiment of the present invention the power amplifier for the energization of said electromagnet, driven by a.c. network voltage, comprises a silicon controlled rectifier (SCR), said enabling gate receiving besides to said signal coming from the piston position detector, a zero crossing signal of the a.c. network voltage and a proper enabling signal coming from a circuit receiving a piston signal, a plurality of electromagnet energization starting signals, at the desired material liquid volume and a possible signal for arbitrary stopping the energization of said electromagnet.

In a particularly preferred and simplified embodiment, the memory controlling the starting and the stopping of the electromagnet energization has just one setting input, obtained by joining together through a logical gate, such as an or gate, the setting inputs of the different meterings and the set input for arbitrary metering and two resecting inputs one connected with the different meterings and another connected to the arbitrary metering.

Specifically, the resetting input of the different meterings comprises an assembly of as many step function generators as the desired meterings and a voltage comparator circuit comparing the voltage of the step function with one or more reference voltages said voltage comparator emitting a resetting signal for the memory when said step function is equal to one of said reference voltages, said assembly operating as a counter and indicator of a desired piston stroke number.

More preferably, said resetting input of the different meterings comprises an assembly of as many step function generators as the desired metering, each of said step function generators providing steps of different heights, and a voltage comparator circuit comparing the voltage of the step signal with a preset reference voltage, said comparator emitting a resetting signal for the memory when said step function equals said reference voltage.

Still more preferably, the step function generators comprise a generator of pulses having strictly equal length derived from the pump piston point position detector, charging a capacitor through one of a plurality of resistors connectable through commuting means so that , by changing the time constant of a circuit provided by said capacitor and one of the resistors, said time constant being anyhow much longer than said pulse length, the heigth is varied of the single voltage steps, leading to the reference voltage with a higher pulse number for lower step heigths and with a lower pulse number for higher step heigths whereby countings of desired pulse numbers are carried out.

Alternately, said reset input of the different metered volumes comprises only one step function generator having steps of desired and fixed and a voltage comparator circuit comparing said step function with one of as many reference voltages as the metered volumes, to be predetermined said voltage comparator emitting a reset signal for the memory when said step function equals one of said voltage references.

Also more preferably the step function generator comprises a generator of pulses, having strictly equal length charging a capacitor through a resistor, which with said capacitor providsd a time constant much longer than the length of said pulses whereby each pulse provides a voltage step, having a fixed and consistent level, and , depending on the reference voltage selected by commutating means, the number of pulses necessary to reach said reference voltage is varied.

Still according to the particularly preferred and simplified embodiment, the use of the setting input for arbritraris metering causes the generation of the step function to be stopped so that the resetting can take place only through the resetting input of the arbitrary metering. According to a first embodiment, the stopping in the generation of the stop signal is obtained by deactivating all the commutating means connecting the plurality of resistors with the capacitor in order to prevent the coupling of the equal length pulses to charge said capacitor.

According to an alternative embodiment, the stopping in the generation of the step function is obtained by firstly short circuiting said capacitor, so that it cannot be charged by said equal length pulses and by deenergizing all the commutating

means by which the reference voltage is selected, whereby the voltage comparator, by which is subjected to a reference voltage which can not be attained to avoid that said voltage comparator causes the memory to be reset.

In another preferred embodiment said commutating means for the step function generator are controlled by memory means settable by separated inputs, the number of which is equal to the number of desired metered volumes and resettable at the end of each metering when said memory for actuating an electromagnet energization is reset.

In said embodiment, according to a first alternative, the memory means control commutating means selectively connecting a plurality of resistors with a capacitor to provide a step function generator having steps of height adjustable .

In said embodiment, according to a further alternative, the memory means control commutating means selectively connecting a plurality of reference voltages with said voltage comparator.

In a further preferred embodiment in order to reduce the number of connecting controls both to the memory controlling the starting and the stopping of the electromagnet energization and to the memories controlling the commutating means of the semplified counter containing a step function generator, there is used a voltage divider consisting of four resistors, serially connected between a D.C. supply voltage and the ground, the two external resistors of said series having substantially double resistance than that of the two internal resistors, the junction between the first and the second resistors being connected to a first input and the junction between the third and fourth resistors being connected to a second input and the junction between the second and the third resistor or central junction of the voltage divider being connected to a control terminal switcheable between the D.C. supply voltage and the ground voltage in order to yield respectively high and low logical states for said first and second imputs.

According to a further preferred embodiment, the pump driving of the electromagnet, provided by a silicon controlled rectifier (SCR) uses an enabling gate connected through an optical coupling to said hale efect pump position detector and a zero crossing detector for the zero point of the network voltage applied to the electromagnet in order to syncronize the pump movement with the said network voltage.

Alternatively, the present invention can also be embodied by using a microprocessor controller providing the function of setting and counting the liquid volume meterings which must be delivered by the pump, said microprocessor comprising at least an input/output (I/O) port, a read only memory (ROM), a random access memory (RAM), an address bus, a data transfer bus, a central processing unit (CPU), a possibly quartz stabilized clock and imput and output connections from and to the periferical units. According to the last mentioned alternative embodiment, the microprocessor controller operates by sending through the input connections of the I/O post to the central processing unit (CPU) the directions con cerning a liquid volume metering to be delivered by the pump, said central processing unit attending on the basis of the information received from the I/O port, to extract from the ROM the information concerning the preselected meterings, said information being possible presented to the RAM in order to extract therefrom numerical data to be presented to the central unit, so that at the end of the phase for determining the stroke number, the central unit sends to the I/O port directions to enable a gate driving a pump electromagnet according to the invention.

Still according to this last embodiment, the energization of the electromagnet controls the position of a pump piston detected by a detector which in turn controls said electro-magnet energisation, producing oscillations by which a liquid pumping is allowed so that, once said oscillations are set pulses arrive to said I/O port corresponding to said oscillations, which pulses are counted by the central processing unit and their total number is compared with the number, stored in the RAM, corresponding to the desired metered liquid volume, so that, when the number of total pulses counted in the CPU coincides with the number stored in the RAM, the central unit emits a stopping direction to the I/O port by which the electromagnet energization and thus the pumping is stopped possibly signalling through displaying devices that a desired liquid metered volume has been delivered.

The features and the advantages of the present invention will be more apparent from the following detailed disclosure given in an exemplifying and not limiting way, of some practical embodiment, thereof with reference to the accompanying drawings wherein:

figure 1 is a block diagram of a first embodiment of an operating system for metering pump, using a numerical data setting device, as a keyboard, to set, time by time, liquid volumes to be metered by the pump;

- figure 2 is a block diagramm of a second embodiment of a metering pump operating system using a numerical data setting device to preset a plurality of selectable liquid volumes, to be metered by said pump, which can be selected at will;

- figure 3 is a schematic picture of a vibrating pump provided with a pump stroke detecting device which is a Hall effect magnetic field detector connectable to said pump casing;

- figure 4 is a graphical depicting hysteresis cycle of a typical magnetic field detector applied to a pump of the of figure 3;

- figure 5 is a block diagram of a electromagnet driving system for vibrating pump, of the kind depicted in figure 1, using for said control a circuit comprising a silicon controlled rectifier (SCR);

- figure 6 is a block diagramm of a first simpliefied embodiment of a pulse counter and numerical comparator circuit to be used in the metering control system of present invention;

- figure 7 is a block diagram of a second and alternative simplified embodiment of a pulse counter and numerical comparator circuit to be used in the metering control system of present invention instead of figure 6 circuit;

- figure 8 shows graphical diagrams ilustrating the operation of figure 6 and 7 circuits;

- figure 9 is a complete circuit diagram of a metering pump control circuit;

- figure 10 is an example of a pair of memory members, of the kind depicted in figure 9, using a memory setting system comprising a minimal number of connections to outside members;

- figure 11 shows a graphical diagrams illustrating the figure 10 circuit operation;

- figure 12 is a circuital diagram of an embodiment of a pump electromagnet driving circuit, corresponding to the block diagram shown in figure 5 and also mentioned in figure 9;

- figure 13 shows graphical diagrams illustrating the figure 12 circuit operation;

- figure 14 shows a a further embodiment of a metering pump driving system controlled by a microprocessor.

Referring to figure 1, a first driving system 10 for a metering pump, of the kind having a piston, comprises a piston position detector 12 emitting an active or high signal when the piston of said pump is close to said detector 12 and a low signal when the piston is far away from said detector (it is possible to devise a detector emitting reverse signals with respect to those of detector 12). The signals provided by the detector 12 are coupled through a line 14, which is divided in a first branch 14a and a second branch 14b, to an enabling gate 16 allowing or preventing the forwarding of the detector 12 signals according to a control signal received from a line 17 whose function will be discussed later on. The gate 16 has an output connected to a power amplifier 18 supplying energy to an electromagnet 20, forming the motor of said vibrating pump by which through mechanical means 22 the position of a movable core of said electro-magnet is transmitted to the position detector 12. The just disclosed assembly of position detector 12, of enabling gate 16, of power amplifier 18 and electromagnet 20 with the mechanical means 22 provides an amplified closed loop driver which through a proper and obvious signal sign selection can be a self oscillating assembly to assure an alternating current component through the electromagnet 20 and thus the movable core movement within said electromagnet.

As it was already stated,, the metering pump according to present invention is based on the fact that the piston stroke of said pump is always the same, so that the liquid volume supplied by the pump is proportional to the number of strokes carried out by the piston and thus for setting a desired liquid volume, it is sufficient to set the corresponding number of piston strokes, said number being counted by one of the many electronic counter means available from the present integrated circuit art, such as, for example, the counter 24 of the figure 1 being discussed. The counting number cumulated in the counter 24 is forwarded through a bus 26 to a numerical comparator circuit 28, comparing the numbers coming from said counter 24 with numbers coming, through a second bus 30, from a numerator or combinator 32 provided, for example, with a key board allow ing the key boarding of the desired numbers.

When the number on the bus 26, coming from the counter 24 coincides with the number on the bus 30 coming from the numerator 32, the numerical comparator circuit 28 emits on a line 34 a disabling or reset signal forwarded through on OR gate 35 to a reset input 34" of a memory circuit 36 such as a flip-flop, whose output 17 is used to enable or disable the gate 16, allowing or preventing a signal forwarding from the piston position detector 12 to the power amplifier 18. The memory flip-flop circuit 36 has further a starting or set input 38 for receiving a signal allowing the starting the pump operation, as well as a disabling or reset supplementar input 34' for stopping the pump at will.

The operation of the metering pump driving system 10 is the following.

Through the key board of the numerator or combinator 32 the liquid volume to be supplied by the pump is predetermined, for example by typing a number on said keyboard, and then, through a push bottom contact connected to the input 38, a starting or set signal is coupled to the memory 36, such as a signal enabling through the line 17 the gate 16. Once the gate is enabled, the signals coming from the detector 12 control the power amplifier 18 driving a current within the electromagnet 20, which, owing to the displacement of the movable core, varies the detector 12 output, causing the oscillation of the driving circuit of the electromagnet 20 and thus the movement of the pump beginning the liquid delivery.

At this time from the detector 12 a pulse train comes out a which is counted by the counter 24 on the output of which numbers appear equal to the received pulse number. These numbers are forwarded to the numerical comparator 28 which can be one of many logic units capable of carrying out this kind of operation, which does not emit any signal when the numbers on its input buses 26 and 30, respectively, are different and emitts a signal when said numbers are equal. The signal emitted by the numerical comparator 28 is forwarded through the line 34 and the OR gate 35 to reset the memory 36, which nullifies the enabling signal on the line 17, interrupting the signal forwarding through the gate 16 and then stopping the energization of the electromagnet 20 and the motion of the pump actuated therefrom. The pump which began to operate owing to a starting command on the start or set input 38, stops after a stroke number has been completed as present by the numerator 32 thus determining the desired liquid volume to the delivered.

Obviously with the driving system of figure 1, it is necessary to set time by time the liquid volume or the corresponding stroke number of the pump, possibly stored in a memory or latch till it is changed by means of the numerator or keyboard combinator 32.

A more practical system 40, depicted in figure 2 wherein parts similar to those depicted in figure 1 are indicated by the same reference numerals, allows to provide and select through simple criteria, such as the actuation of a plurality of push-buttons or the sending of a signal to one of a plurality of input connectors 38a, 38b,...38n, 38' controlling the start or set of a flip-flop memory circuit 36 through a multiple input OR gate 37, having an output connected to the setting input 38" of said flip-flop 376, one among many possible metered amounts previously preset by the numerator or keyboard combinator 32. In this case the output bus 30 of the key board combinator 32 is divided in a number input branches 30a, 30b,...30n for corresponding numerical comparator assemblies 46a, 46b, ... 46n, having another input 26a, 26b,... 26n, connected to the output 26 of a pulse counter 24 and their respective output lines 34a, 34b,.... 34n, combined in the OR gate 35 at the reset input 34" of the flip-flop 36 and further each having an actuation or enabling input 39a, 39b, ..., 39n connected to the connectors 38a, 38b,.... 38n respectively and a common disabling input connected to an inverted output line 19 of the flip-flop 36, said flip-flop 36 having a direct output 17, which likewise to what happens in figure 1, actuates the enabling gate 16. Specifically, each numerical comparator assembly 46a, 46b...., 46n, can be meant as provided by a numerical comparator 50, a flip-flop memory 51 and an addressable latch 52, by which a number coming from the numerator or combinator 32 through one of the bus branches 30a, 30b, ... 30 is maintained on record, when an address signal coming from said combinator 32 enables the corresponding latch 52.

However, it is to be pointed out that if the metering requirements were invariable, i.e. if a certain number of invariable metered volumes would had to be selected, the numerator or combinator 32 and the connecting buses 30a, 30b,.... 30n might be eliminated, each latch 52 being replaced with a proper logical circuit, capable of expressing the desired number or with a read only memory (ROM) caable containing the number to be compared with the number emitted by the counter 24 to provide on the respective output lines 34a, 34b,... 34n the reset signals to be forwarded through the OR gate 35 to the flip-flop memory circuit 36.

The operation of the circuit depicted in figure 2 is the following: once the numerical data to be introduced in the latch 52 of the numerical comparator assemblies 46a, 46b,... 46n through the connecting buses 30a, 30b,... 30n have been determined by numerator or key board combinator 32, it is sufficient to forward a starting signal to one of the start control inputs 38a, 38b, ... 38n, 38', of the OR gate 37 on the set input 38" of the flip-flop memory 36 to actuate the gate 16 allowing the signal forwarding from the position detector 12 to the power amplifier 18, then to the electromagnet 20, finally closing the circuit loop through the mechanical connecting means 22 and allowing the starting of an oscillatory movement of the pump piston. Once the movement of said pump piston starts, the counter 24 begins to court the strokes of said piston, presenting the total number of said strokes to the numerical comparator assemblies 46a, 46b,... 46n. Everytime the counter 24 reaches a number recorded in one of the latches 52 of one of said numerical comparator assemblies, whose input 39a, 39b,... 39n has been actuated by the corresponding connection 38a, 38b,...., 38n said assembly emits a reset signal on the corresponding out-put 34, 34b,..., 34n, which through the OR gate 35, does reset the memory circuit 36.

The resetting of the memory circuit 36 emits on its inverted output a signal which, through the line 19, deactuates the previously actuated numerical comparator assembly, and resets on the output 17 the actuating or enabling signal for the gate 16, stopping the operation of the metering pump.

For a better understanding of the present invention, it is necessary to consider in more detail a vibrating pump having associated a piston position or pump stroke detector, as depicted in figure 3. Said vibrating pump provided with a piston position detector is the subject of the Italian utility Model

Patent Application No. 21,796 B/84 filed on May 15, 1984, and having as inventor the same inventor of the present invention.

According to the above said figure, a vibrating pump 60 comprises an electromagnet coil 62 wound on reel 64 surrounding a tubolar seal tight chamber 66 within which a movable core 68 is displaceable and is maintained in the position shown in the figure by a spring 70. The movable core 68 extends in a pump piston 72 movable within a pump housing 74, having the shape of a cylinder narrower that the tubolar chamber 66. Said piston 72 in the pump housing 74 has a like behaviour as the piston of a syringe, displacing for ea stroke a liquid volume substantially equal to the volume of said stroke, so that the total liquid volume displaced by the pump results, as already stated, proportional to the stroke number thereof and thus to the vibration cycle number of the movable core 68.

The only thing which must be done for evaluating the metered volume of liquid displaced by said vibrating pump is to count the vibration cycle number of the core 68, having the care of obtaining a signal pulse for everyone of said cycles. For obtaining said pulse it is necessary to have a piston position detector emitting a signal every time the pump piston 72 is in the same position, for example in its maximal extension position, when, failing any current through the coil 62 of the electromagnet, the spring 70 pushes the movable core 68 and thus the pump piston 72 in said position.

One among the most proper position detectors for the piston 72 is a Hall effect magnetic detector provided with feeding terminals 78 and 80 and with at least an output terminal 82. Said detector is assisted in the operation by a permanent magnet 84 and by a calibrating screw 86 having the hereinbelow discussed functions. The permanent magnet 84 produces a first field H_M having a given direction, the coil 62 crossed by a variable but unidirectional current produces a second field having strenght $-H_B$ in opposite direction with respect to that of the permanent magnet 84. when the coil 62 is crossed by current, the Hall effect magnetic detector 76 is submitted to a magnetic field strength $H_1 = H_M - H_b$ producing a low current absorption on its output terminal 82, while when the current through the coil ceases the magnetic detector 76 is submitted to the field strength $H_2 = H_M$ which produces a high current absorption on its output terminal 82. This fact is specifically depicted in figure 4 showing the level of the current I_{82} absorbed at the terminal 82 of the magnetic detector 76 versus the field strength to which the detector is submitted. It is to be noted that the transfer from low to high current takes place substantially at the strength $H_2 = H_M$, while the reverse transfer takes place the strength $H_1 = H_M - H_B$ quite different and lesser than H_2, determining a hysteresis cycle supporting the most neat and the quickest possible status changes, which make the detector of the present invention specifically proper to control digital circuits.

Obviously it is not necessary that, as depicted in figure 4, H_1, and H_2 are symmetrical with respect to the origin of the axes as they could be both at the right or at the left of said origin.

The calibrating screw 86 is essential in getting a magnetic gap which, the current in the coil 62 and the permament magnet 84, being the same does set the best status change points at the detector 76.

An embodiment of the invention, as substantially suggested by the block diagram of figure 1, is depicted in more detail in figure 5.

According to such an embodiment comprising with an electromagnet 20 directly supplied by the a.c. netword voltage, there is always a piston position detector 12 controlling through an enabling gate 16a a power amplifier 18 operating with a.c. supply, said enabling gate 16a receiving a driving signal from the position detector 12 through a line 14a, a first enabling or actuation signal from a starting, stopping and numerating system 90 through a first line 17a, and a syncronizing signal with the a.c. electric network from a zero crossing detector 92 through a second line 17b. The enabled and syncronized signal coming out from the enabling gate 16a, comes in as driving signal to the amplifier 18 which in the present case supplying the electromagnet 20, from the network voltage is a circuit containing at least a silicon controlled rectifier (SCR) 94 allowing the electromagnet 20 to be crossed by a unidirectional current controlled by the position detector 12 through the enabling gate 16a. Said SCR amplifier is advantageous for driving the electromagnet 20 because it permits a direct supply thereof by the electrical network and interrupts by itself at any network alternativ inversely biasing the SCR. The starting, stopping and numerating system 90 may contain for example the components 24, 28 and 36 of figure 1 which control the pump starting allowing a first current pulse through the electromagnet 20 when a start signal arrives to one of the terminals 38a, 38b,....n 38n, 38′ and then allowing the transit of driving pulses from the piston position detector 12 to the power amplifier 18 to permit the pump piston oscillation, then counting the detector 12 pulses until they are equal in number to a preset number on a line 30k, at what time the enabling gate 16a, disable or disabling the gate 16a, owing to a stop signal received on one of the terminals 38a, 38b,... 38n, 38′. In an alternate form of this specifical embodiment the enabling signal insteadt of reaching the

gate 16a through the line 17a, might consist of an actuating signal 95 for an auxiliary contact pair 96 on one of the network terminals 98 and 100 connecting said electromagnet 20 and power amplifier 18 to the supply network.

Reference is made to figure 6 depcting a first embodiment example of a pulse counter and numerical comparator circuit useful to control metered liquid volumes to be supplied by the pump, starting the pump and stopping it upon a stroke number preset by a delyy circuit contained in the present pulse counter is carried out.

Said pulse counting circuit essentially comprises a first monostable one-shot circuit 110, receiving on a terminal 14b the pulses coming from a piston position detector 12 (shown in figures 1, 2 and 5) and provided with a capacitor 112 and a resistor 114 to produce pulses, having equal time length, emitted by the monostable circuit 110. Such pulses pass through a diode 116, switching means 118 and one of a plurality of variable resistors 120a, 120b, 120c and 120d to charge a capacitor 122 raising the voltage thereon. Said capacitor is also connected to a non inverting input of a voltage comparator 124 whose inverting input is connected to a reference voltage + V_R. The output of the voltage comparator is connected to resetting or deactuating input of a bistable circuit 126 receiving a setting or actuating signal at another input 127 and a further resetting or deactuating signal at another input 128. Said bistable circuit 126 emits on a line 130 a signal having two purposes: actuating the auxiliary contact pair 96 (enabling the pump operation) and forwarding through a further line 132 a blocking signal for the input state of a memory circuit 134.

Said memory circuit 134 is a circuit receiving actuating signals from input terminals 136a, 136b, 136c and 136d emitting them from output terminal 137a, 137b and 137d to actuate both one of the gates of the switching means 118 and an input or an OR gate 140 whose output through a delay circuit 142 is coupled to the setting or actuating input 127 of the bistable circuit 126.

The embodiment example depicted in figure 7 is an obvious alternative of the figure 6 embodiment, differing from that just for the fact that to determin the number of pulses, coming from the monostable circuit 110, corresponding to a desired liquid volume to be displaced, instead of using voltage increments, at the non inverting input of the voltage comparator 124, having variable amplitude according to the time constant RC determined by one of the variable resistors 120a-120d and by the capacitor 122, obtaining a state change of the bistable circuit 126 when the voltage on the non-inverting input is equal to the voltage on the inverting input, is used a constant voltage increment depending by the time constant RC determined by a fixed resistor 120 and by the capacitor 122 and are used different reference voltages by connecting the inverting input of the voltage comparator 124 through the switching means 118, to movable contacts of a plurality of potentiometers 121a, 121b, 121c, and 121d, determining as many reference voltages for said voltage comparator 124.

The comparative operation of both embodiments of figures 6 and 7 is depicted in the graph of figure 8. In said graph the diagram a) shows the pulses coming from the piston position detector 12 appearing on the terminal 14b, the diagram b) shows how said pulses are processed by the monostable circuit 100 in pulses having constant time length, the diagram c) shows the signal appearing on the output terminal 130 of the bistable circuit 126, the diagram d) shows the voltages appearing at the two inputs of the voltage comparator of figure 6 and the diagram e) shows the voltages at the two inputs of the voltage comparator 124 of figure 7.

The definite understanding of the operation of both the above mentioned circuits is obtained by considering figure 6 with the corresponding graphs in figure 8, as well as the figure 7 and its corresponding graphs in figure 8.

When one the preset volumes is desired, one of the inputs in 136a-136d of the memory 134 is actuated, for example by putting a high voltage level on said input, so that the corresponding output 137-137d becomes high. The high state of one of said outputs goes through the OR gate 140 and the delay circuit 142, having the duty of eliminating transitory noise and incidental or undesired actuations of memory 134 inputs to the setting or actuating input 127 of the bistable circuit 126 whose output on the terminal 130 becomes high, as depicted in the diagram c) in figure 8. The high output on the terminal 130 closes the contact pair 96 allowing the energisation of the pump electromagnet 20 (shown in the figures 1, 2 and 5) and the same high output through the connecting line 132, maintains the state of the memory 134 so that the one of its outputs 137a, 137b, which was actuated, remains actuated independently from the further state taken by the corresponding input 136a-136d. Taking it into account that, as the pump begins to operate, on the terminal 14b there appear the pulses shown in the diagram a) of figure 8 and thus at the output of the monostable circuit 110 appear the pulses shown in the diagram b) of figure 8. Being said output connected to the one of the variable resistors 120a-120d corresponding to one high of the outputs 137a-137d, the capacitor 122 is charged, according to a time constant RC determined by its capacity and by the resistance of the connected resistor among the variable resistors

120a-120d, during the time in which the pulses of the diagram b) are high, receiving for each charg a voltage increment whose amplitude is substantially inversely proportional to the length of the time constant RC (it happens everytime the time constant RC is much longer than the length of the pulses b) coming out from the monostable circuit 110), so that the voltage on said capacitor 122 increases for each pulse b) an depicted in the diagram d) of figure 8, charging from 0 to the voltage V_R and , if each voltage increment is one n^{-th} of the voltage V_R , n pulses, corresponding to n pump strokes, are necessary in order to reach on the capacitor 122 the voltage level $+V_R$ present on the inverting input of the voltage comparator 124. When the voltage on the capacitor 122 reaches said level $+V_R$, the voltage comparator 124 deactuates the bistable circuit 126 lowering its output on the terminal 130 which opens the contact 96, stopping the pump and, at the same time relieves the state of the memory 134, making its outputs equal to the inputs. It is to be noted from the diagram d) of fig. 8 that the pump stroke number depends on the time constant RC determined by the capacitor 122 and by one the variable resistors 120a-120d, it being understood that for a shorter time constant R_1C_1 the voltage + V_Rs is reached at the time t_1 corresponding to two pump strokes, for a longer time constant R_2C_2 the voltage $+V_R$ is reached at a time t_2 corresponding to three pump strokes and for a third still longer time constant R_3C_3 the voltage + V_R is reached after five pump strokes. Obviously these pump stroke numbers are given just for a simple indication it being meant that as matter of fact said pump stroke numbers are always much higher (of the order of tenths or hundreds).

Likewise for the figure 7 embodiment, taking it into consideration the diagrams a), b), c), e) of figure 8, when one of the preset volumes is desired, one of the inputs 136a-137d of the memory 134 is actuated for example applying a high voltage level on said input, so that the corresponding output becomes high. The high state of one of said outputs goes through the OR gate 140 and the delay circuit 142, having the duty of eliminating transitory noise and incidental or unwanted actuations of the memory 134 inputs at the setting or actuating terminal 127 of the pistable circuit 126 whose output on the terminal 130 becomes high, as depicted in diagram c) in figure 8. The high output of the terminal 130 closes the contact pair 96, allowing the energisation of the pump electromagnet 20, (shows in figures 1, 2 and 5) and the same high output through the connecting line 132, maintains the state of the memory 134, so that the one of its outputs 137a-137d which was actuated, remains in such a condition independently from the further state taken by the corresponding input 136a-136d, just exactly as it takes place in figure 6 embodiment. Likewise to what takes place in figure 6 embodiment, as the pump operation is started at the terminal 14b of figure 7 and then at the output of the monostable circuit 110, the pulses depicted in the diagram b) of figure 8 appear.

Being said output connected through the diode 116 and the resistor 120 to the capacitor 122, the latter will be charged, according to a time constant RC determined by the resistance of the resistor 120 and bt the capacity of the capacitor 122 undergoing for each pulse b) a voltage increment which is substantially inversely proportional to the length of said time constant RC. The voltage on said capacitor 122 and thus on the non inverting input of a voltage comparator 124, increasing by a fixed increment for each pulse b) until it becomes equal to a voltage applied to the inverting input ouf the same comparator 124 and obtained by connecting through switching means 118 said inverting input to one of a potentiometer plurality 121a-121d each setting a reference voltage V_{R1}, V_{R2}... for said comparator 124.

As clearly visible in the diagrams c) and e) of figure 8, according to the preselected reference voltage, the output 130 of the bistable circuit 126 will remain high for a longer or shorter time. In fact if the reference voltage V_{R1} is set by connecting the inverting input of the comparator 124 to the first potentiometer 121a, the pump will stop at the time t'_1 corresponding to two pump strokes; if the reference voltage V_{R2} is set, the pump will stop at the time t'_2 corresponding to three pump strokes, and if the reference voltage V_{R3} is set, the pump will stop at the time t'_3 corresponding to five pump strokes. Obviously these pump stroke numbers are given just for an indication, since as a matter of fact said pump stroke numbers are always much higher (of the order of tenths or hundreds).

It is to be noted that both the circuits of figures 6 and 7, are provided in addition to the inputs 136a-136d for counting preset numbers of pump strokes corresponding to preset liquid metered volumes, also with an independent terminal 138 to start a continuous operation of the pump, and with an independent terminal 128 to stop said continuous operation, in order to obtain liquid metered volumes of arbitrary entity. Said independent inputs operate by activating and deactivating the bistable circuit 126, respectively.

Let us consider first figure 6. When the terminal 138 is actuated, for example by applying to on the same a high voltage level, said level arrives through the OR gate 140 and the delay circuit 142 to the actuating terminal 127 of the bistable circuit 126 which through its output terminal 130, closes the contacts allowing the electromagnet 20 of the

pump to be energized (figures 1,2 and 5). When the bistable circuit has been actuated or set, it remains in that state until arrives a deactuating or set signal arrives to the terminal 128 because, as none of the terminals 136a-136d of the memory 134 has been actuated, none of the switching gates 118 is conducting and thus no pulse coming from the monostable circuit 110 is able to charge the capacitor 122 for operating the voltage comparator 124 providing the resetting of the bistable circuit 126. Thus if the bistable circuit 126 cannot be reset or deactuated by the comparator 124, it can be reset just by the terminal 128. In conclusion, the terminal 138 starts a continous operation of the pump and the terminal 128 stop, it without any intervention of the pump stroke counting circuits.

Likewise operates the figure 7 circuit, but its whole operation is a little more complicated since, besides to preventing the pulses coming the monostable circuit 110 form reaching the voltage comparator 124, at the inverting input thereof such a reference voltage must be assured which can never be execeded by voltages possibly present an the non inverting input.

In order to prevent the arrival of the pulses on the non inverting input of the comparator 124, a circuit is provided containing an OR gate 141 and a diode 143 mantaining the low voltage level on the capacitor 122 when does not actuating signal on at least one of the terminals 136a-136d. To ensure a reference voltage high enough on the inverting input of the voltage comparator 124 a resistor 123 is provided permanently connected between the d.c. supply voltage $+V_1$ for the electronic circuits and said inverting input. Said resistor is selected with such a high resistance as to not substantially affect the voltage levels provided by the potentiometers 121a-121d when one of said potentiometers is connected through one of the switching gates 118 to said inverting input of the voltage comparator 124, although permitting to provide a reference voltage substantially equal to $+V_1$ when no potentiometer is connected. In conclusion, also in the figure 7 circuit the terminal 138 starts a continous operation of the pump and the terminal 128 stops it without any intervention of the pump stroke counting circuits.

Reference is made to figure 9 depicting in detail a complete metering pump circuit using the pump stroke counting system of figure 6. As depicted in said figure 9, the position of said pump piston is detected by the Hall effect magnetic detector 76, whose terminals 78 and 80 are connected to the supply voltage $+VC_1$ and to ground, and whose output terminal 82, consisting an unconnected collector of a transistor, is connected from one side to an inverting input of a OR gate 111 and from the other side to a series circuit comprising a resistor 146 and a light emitting diode (LED) 148 connected to the supply voltage $+V_1$. The light emitted by said diode 148 arrives through a proper optical path 149 to a a circuit 150 driving the electromagnet 20 assuring a current crossing through said electromagnet every time the Hall effect detector 76 feels the proximity of the pump piston symbolized by the dashed-dotted line 22. The low state appearing on the output terminal 82 of the detector 76 is changed in a high state at the inverted input of the OR gate 111 and enters the monostable circuit 110, which assures at its output a voltage pulse whose time length depends on the time constant determined by the capacitor 112 and by the resistor 114. Thus, everytime the output 82 of the detector 78 changes from a high to a high state and thus, inversely, the inverted input of the OR gate 111 changes from a low to a high state, at the output of the monostable circuit 110 a high pulse is formed having time length determined by the capacitor 112 and by the resistor 114. Said pulse is forwarded through a protecting resistor 117 and a diode 166 to a switching gate 188 equivalent to four parallelly connected contacts between the cathode of said diode 116 and the variable resistors 120a-120d, said contacts being able to be closed selectively by one of the control terminals 137a-137d coming from the memory assembly 134, which selects what circuit must be closed between the cathode of the diode 116 and one the variable resistors 120a-120d.

The variable resistors 120a-120d together with capacitor 122 set the time constants R_1C_1,R_2C_2, R_3 C_3, R_4C_4 with which is charged the capacitor 122 connected to a deactuating or resetting input of the bistable circuit 126, so that the voltage on said input reaches a level high enough for the resetting just after that on the capacitor 122 are accumulated as many voltage increments, corresponding to pulses coming from the monostable circuit 110, as they are set by the time constant determined by the capacitor 122 and by one of the resistors 120a-120d. When said resetting level is reached, the bistable circuit 126 is deactuated through a mechanism hereinbelow explained in detail. Turning to the particulars it is seen that the bistable circuit 126 has a double setting or actuating input 127a consisting of an OR gate having a direct input and an inverted input, a direct resetting input 160 connected to the capacitor 122, an inverted resetting input 128, a direct output 162 and an inverted or complementary output 164. The direct output 162 is connected through a resistor 166 to the base of a resistor 168 driving a relay 170, provided with a free weeling diode 172 which through a mechanical connection 95 actuates contact pairs 96 and 96a, providing for the anabling of the above mentioned driving circuit 150 of the

pump electromagnet 20 and the actuation of signalling or auxiliary devices such as lights, powder meters, etc.. The inverted output 164 is connected through a line 132 to the control memory 134 for blocking the same, i.e. to retain the states introduced through the inputs 136a-137d. Specifically when the output 164 is high and thus the bistable circuit 126 is reset, the memory 134 is transparent, i.e. its outputs 137a-137, can take the states of the corresponding inputs 136a-136d, while when the output 164 is low and thus the bistable circuit 126 is actuated, the memory is maintained i.e. it retains the states present on the output 137a-137d; independently from the state of the inputs 136a-136d, this specifically helping for avoiding that a different metered volume is selected when the pump is operating for the delivering of a preset metered volume.

The non inverted actuating or setting input 138 on the OR gate 127a and the deactuating or resetting input 128 are connected to a network comprising a series connected resistor assembly 180-186, in turn connected between the d.c. supply voltage $+V_1$ and ground. Specifically said resistor series connected network comprises two resistors 180 and 186 and two resistors 182 and 184, said resistors 180 and 186 having substantially double resistance with respect to the two resistors 182 and 184, so that on said network operating as a voltage partitor at the junction of the resistors 180 and 182 there is a voltage of 2/3 V_1, at the junction of the two resistors 182 and 184 there is a voltage of 1/2 V_1 and at the junction between the resistors 184 and 184 a voltage of 1/3 V_1.

This specifical resistor network 180-186 connected between the supply voltage $+V_1$ and ground although not strictly necessary in the present invention, allows just one terminal 228/238 to be used for obtaining the manual setting and resetting of the bistable circuit 126, as it will explained in more detail hereinbelow in the figures 10 and 11 for two similar networks of resistors 192-198 and 200-206 connected to the respective inputs 136a-136d of the memory 134.

It is also to be noted a capacitor 138, connected between the input 128 and ground, allowing to have the bistable circuit 126 always reset for any energisation or turning-on of the apparatus and a capacitor 190 connected between the input 138 and $+V_1$ for eliminating transient noise.

To complete the description of the embodiment of figure 9 it is seen that said circuit is provided, for the supplying from the a.c. electric network, with a transformer 210 having primary winding 212 connected to the terminals 90 and 100 of the electric network and secondary winding 214 connected to the input of a bridge rectifier 216 whose output is connected to a first levelling capacitor 218 on which a first higher voltage is formed substantially equal to the voltage $+V_2$ between a resistor 220 and ground, having the duty of supplying the relay 170 driven by the transistor 168. The same output of the rectifier 216 is connected to the input of a stabilizer 222, on the output of which, provided with a second levelling capacitor 224, a lower stabilized voltage $+V_1$ appears supplying all the electronic circuit present on a printed circuit card depicted in said figure 9.

To the network terminals 98 and 100 a driving circuit 150 for the pump electromagnet 20 is also connected, receiving actuation from the contact pair 96 and a control signal from the optical path 149 with the light emitting diode (LED) 148 driven by the Hall effect magnet detector 76. Referring to figures 10 and 11, by which two elements 134a and 134b of the memory 134 are taken into consideration, it is seen how operates one of the two networks of four resistors connected as voltage partitors to supply on just one terminal the signals for two inputs of the memory 134, it being understood that said principle equivalentely applies to the four resistor network supplying signals to the inputs 128 and 138 of the bistable circuit 126. Specifically, as already told for the network of resistors 180-186, in figure 9 the resistor network 192-198 comprises two external resistors 192 and 198 having double resistance with repsect to two internal resistors 194 and 196 so that, by indicating with $+V_1$ the supply voltage , on the terminal 136a connected to the junction between the resistors 192 and 194 a voltage appears 2/3 V_1, on the intermediate terminal 250 the voltage 1/2 V_1 appears and on the terminal 136b the voltage 1/3 V_1. appears. Looking at figure 11 together with figure 10, it is seen what happens when the terminal 250 is connected to ground voltage or to $+V_1$ voltage, by closing the contact pairs 236a or 236b, respectively.

In the first case the voltage on the terminal 250 falls from 1/2 V_1 to zero, while the voltage on the terminal 136a lowers from 2/3 V_1 to 1/3 V_1 and the voltage on the terminal 136b lowers from 1/3 V_1 to zero. In the second case the voltage on the terminal 250 raises from 1/2 V_1 to $+V_1$, while the voltage on the terminal 136a raises from 2/3 V_1 to $+V_1$ and the voltage on the terminal 136b raises from 1/3 V_1 to 2/3 V_1. Taking now into consideration that in may integrated circuits usable in the present invention (such as the CMOS circuits) the voltages lower than 45% of the supply voltage are considered low states, and high states the voltages higher than 55% of the supply voltage, with an uncertainty region of about 10% of said voltage, as depicted in figure 11, it is apparent that the closure of the contact pair 236a brings in a low state (logical 0) both inputs 136a and 136b of the mem-

ory members 134a and 134b, while the closure of the contact pair 236b brings in a high state (logical 1) both inputs.

As of the memory member 134a the inverted output is used, while of the memory member 134b the direct output is used, it happens that when both memory inputs 136a and 136b are low, the memory output 137a is high and the memory output 137b is low, while vice versa, when both memory inputs 136a and 136b are high, the memory output 137a is low and the memory output 137b is high.

The same figure 11 depicts also the operation of the memory blocking signal appearing on the terminal 132, also depicted in figures 6,7,9 and 10. It is known that said memory blocking signal is high when the bistable circuit 126 is deactuated or reset and is low when it is actuated or set and the specific memory 134 is so made that when the blocking signal is high the memory members 134a-134b are transparent, i;e. the state of their output becomes equal to the state of their input, while when the blocking signal is low the memory members are blocked or i.e. they maintain the state given by their input before said blocking signal becomes low.

Thus when the contact pair 236a is closed the output 137a of the memory member 134a becomes high actuating or setting the bistable circuit 126, after the delay imposed by the delay circuit 142, said actuation remaining until all the pump strokes corresponding to the desired metered volume have been carried out, lowering the memory blocking signal 132 retaining the output states of the memory members 134a-134d, i.e. in this case maintaining high the output 137a of the memory member 134a and low the output 137b of the memory member 134b.

When the time t_1 corresponding to the preset pump stroke number has elapsed, the bistable circuit 126 is deactuated or reset, making still high the state of the blocking signal on the terminal 132 and thus making transparent the memory members 134a-134d. In this case, as the contact pair 236a is reopened, the output 137a of the memory member 134a takes again the inverse of the state of its input 136a and thus no actuating signal is anymore sent to the bistable circuit 126.

When the contact pair 236b is closed, the voltage on the terminal 250 raises from 1/2 V_1 to + V_1, that on the terminal 136a raises for 2/3 V_1 to + V_1 and that on the terminal 136b raises from 1/3 V_1 to 2/3 V_1. Thus the state of the terminal 136a high, while the state of the terminal 136b changes from low to high. Being at this time the signal on the terminal 1322 high, the high state on the input of the terminal 136b of the memory member 134b is transferred to its output terminal 137b, emitting an actuation signal for the bistable circuit 126. When the bistable circuit 126 has been actuated, the blocking signal becomes low, retaining the state on the output terminal 137b of the memory member 134b and maintaining it until it remains low in a perfectly equivalent way with what happened for the signal on the output terminal 137a of the memory member 134a.

Figure 10 depictes also a simple provision to avoid possible misfunctions deriving from a contemporaneous closure of both contact pairs 236a and 236b. Said provision consists in inserting two resistors 240 and 242, respectively having equal resistance as a very small fraction of the resistance of resistors 192-198. As an example of practical values these resistances would be 100K ohms for the resistor 192 and 198, 47K ohms for the resistors 194 and 196 and 2.7K ohms for the resistors 240 and 242.

The presence of said resistors 240 and 242 should not have any substantial effect on the state of the input terminals 136a and 136b, when just one contact pair 236a or 237b is closed, while in the case of contemporaneous closure of both contact pairs, equal resistances of the resistors 240 and 242 should not change the voltage level on the terminal 250 which would remain at the same level of + 1/2 V_1 which is already preset when both the pairs 236a and 236b are open. The only consequence is some current through the resistors 240 and 242 which, however, can be limited to absolutely bearable levels with a proper selection of their resistance (for example to the above indicated values).

Reference is now made to figures 12 and 13 respectively depicting a preferred embodiment of the driving circuit 150 of the electromagnet 20 shown in figure 9 and its operating manner.

Referring to figure 12, said driving circuit 150 comprises an enabling gate 16a, controlled by a light signal emitted by the diode 148 through the optical path 149, comprising a transistor 260 whose base is driven by the collector of a phototransistor 262 forming with the light emitting diode 148 an optical coupler loaded by a resistor 264 operating also as byasing and feed-back resistor connected between collector and base of the transistor 260, said transistor having the collector connected to a load resistor 266 supplied by a rectifying circuit comprising a diode 270, a resistor 268 and a levelling capacitor 272. Near the enabling gate 16a a zero crossing detector 92 for the network a.c. voltage is formed comprising a transistor 274 having emitter and collector commonly connected with the emitter and collector of the transistor 260 and a base 275 connected to a voltage divider, comprising resistors 276 and 278, connected through a diode 280 to a network terminal (e.g. the terminal 98). The collector of the transistor 274, connected

in common with the collector of the transistor 260, is connected through a voltage divider, comprising resistor 282 and 284, to a gate 286 of the controlled rectifier (SCR) 94. With reference also to figure 13, let us consider the operation of said driving circuit 150.

When the electromagnet 20 is not crossed by current, the piston 72 is in the position nearest to the Hall effect magnetic detector so that said detector emits the high signal through the optical path 149. However, this signal does not have and effect unti a request of pump actuation appears closing the contact pair 96 (time T_0). When this contact pair is closed, the network alternating voltage present on the terminals 98 and 100 is applied to the electromagnet 20 and SCR 94 assembly, as well as to the zero crossing detector 92. When a half wave of the network voltage occurs passing through the diodes 280 and 270, both the enabling gate 16A and the zero crossing detector 92 are fed . Being the light signal present in the optical part path 149, the phototransistor 262 of the ptical coupler is saturated, meaning that the base of the transistor 260 is substantially short circuited with its emitter, interrupting the transistor 270 and allowing the appearance on the gate 286 of the SCR 94 of a pulse making conductive said SCR 94 through which SCR a current begins to pass soon as the network voltage reaches a level as to allow the formation of a voltage V_E on the electromagnet 20 and a substantial current I crossing through said SCR 94.

However the pulse on the gate 286 is time limited by the intervention of the transistor 274, on the base 275 of which a voltage is formed connected with the network voltage half wave saturating it, zeroing the voltage on the gate 286 and removing the control form the SCR 94. A current crossing through the electromagnet 20 and the SCR 94 causes the pump piston 72 to be displaced and removed from the Hall effect magnetic detector until the point P_1 is (corresponding to the magnetic field strength H_1 of figure 4) where the output of the magnetic detector and thus the light signal on the optical path 149 goes to zero. The signal absence in the optical path 149 interrupts the phototransistor 262 and saturates the transistor 260 preventing the pulse formation on the gate 286 of the SCR 94 even when that is allowed by the half wave of the network voltage. In the meantime the piston 72 of the pump, pushed by the return spring, comes back to the starting position till a point P_2 (corresponding to the magnetic field strength H_2 of figure 4) in which the output of the magnetic detector is recovered and thus the light signal through the optical path 149.

As it is apparent from figure 13, if the piston 72 has not come back enough to allow the signal generation through the optical path 149, the positive half wave of the network voltage can not provide a control pulse on the gate 286 of the SCR 94 preventing a current passage through the electromagnet 20, said control pulse being generated just when light signal through the optical path 149 exists and thus when the piston has come back near enough to the magnetic detector to allow a complete stroke.

The drive and control system of the present invention can also be embo died using a microprocessor, as depicted in figure 14, carrying out all the operations for presetting and counting metered liquid volumes to be delivered by the pump.

As depicted in figure 14, the electromagnet 20, the piston position detector 12, the enabling gate 16 and the power amplifier 18 assembly can be controlled through said enabling gate 16 by a microprocessor 290, said microprocessor comprising at least an input/output (J/O) port 292, a read only memory (ROM) 294, a random access memory (RAM) 296, an address bus 298, a data transfer bus 299, a central processing unit (CPU) 300, a clock 302, possibly stabilized by a quartz 304, and input and output connections to and from peripherical circuits 306 and 308 respectively.

The operation of the above mentioned microprocessor control 290 is the following:

Through the input connections 306 of the I/O port 292 there are forwarded to the central processing unit 300 the directions regarding the metered liquid volume to be delivered by the pump. Said central unit 300 from the directions received by the I/O port provides to extract from ROM 294 the information regarding the preselected voumes. Said information can be presented to the RAM 296 to extract from it the numerical data to be presented to the central processing unit 300. After the stroke number determination, the central unit 300 forwards to the I/O port 292 directions for enabling the gate 16 (for example through a branch 17 of the output connections 308 of said port 292). The actuation of the enabling gate 16 connects the branch 14a of the connector 14, coming out from the piston position detector 12, with the input of the power amplifier 18 which begins to drive the electromagnet 20 controlling through the mechanical fed-back connection 22 the piston position detector 12.

The oscillations driving the pump piston are then established , causing the liquid pumping. When the oscillations have been established, the branch 14a of the connection 14 forwards pulses to the I/O port 292, the pulses corresponding to said oscillations, which are counted in the central unit 300 and their total number is compared with the total number stroed in the RAM 296, corresponding to the desired liquid volume. When the pulse num-

ber totalized in the central unit 300 coincides with the number stored in the RAM 296, the central unit emits a stopping direction to th I/O port 292, which provides to forward said directions through the connection 17 to the enabling gate 16, stopping the electromagnet 20 driving, and simultaneously forwards through the output connections 308 directions to possible displays indicating the complete delivery of the desired liquid volume or in any case, the carrying out of the directions. Of course just some embodiments have been specified of the present invention not to be construed as limiting the most general principles thereof, it being meant that to people skilled in the art from the reading of the above description many equivalent solutions, can be apparent all to be meant as covered by the scope of the present application.

Claims

1. In a metering pump of the vibrating kind able to operate in variable flow rate condition, comprising a piston driven by a movable core, displaced by an electromagnet (20), a piston position detector (12), an enabling gate (16) between said piston position detector and a power amplifier (18) driving said electromagnet (20) , a device characterized by a memory circuit (36) set by an energisation starting signal (38) for said electromagnet (20) through said memory circuit (36) and said enabling gate (16), a counter (24) counting pulses coming from said piston position detector (12) and the numerical comparator circuit (28) to compare numbers in digital format coming from said counter with numbers coming from a digital combinator or numerator device (32) for supplying a number corresponding to desired metered volumes, said numerical comparator circuit (28) emitting a resetting signal from said memory circuit (36) to stop the energisation of said electromagnet (20) when the number appearing at the output of the counter (24) coincides with the number appearing at the output of the digital combinator or numerator (32), said above mentioned memory (36) further comprising a supplementary reset input (34) to arbitrarily stop the energization of the electromagnet (20).

2. In a metering pump according to claim 1, the device containing a numerical combinator or digital numerator (32) is a key board device similar to the device used for digital remote controls or for phone dialling key boards.

3. The metering pump, according to claims 1 and 2, characterized by leaving said memory (36) set by one preselected of a plurality of electromagnet (20) energisation starting signals (38a-38n; 38') and a plurality of numerical comparator devices (46a-46n) receiving: a) in common the output (26) of said digital counter (24); b) the output (30) of said digital numeral combinator (32), comprising a first digital address signal for one of said numerical comparator devices (46a-46n) and a second digital signal corresponding to desired metered volumes; c) an actuation signal (39a-39n) associated to one of said electromagnet (20) energisation signals (38a-38n); d) a deactuating signal (19) associated with said memory (36) resetting and said electromagnet (20) deenergisation, each of said numerical comparators (46a-46n) emitting a resetting signal (34a-34n) for said memory circuit in order to stop said electromagnet (20) energisation when the number appearing at the counter (24) output coincides with the number appearing at the output of the digital combinator or numerator device (32) forwarded to that numeral comparator (46a-46n) actuated by said signal (39a-39n) associated to the preselected electromagnet (20) energisation starting signal 38a-38n) and further comprising and additional input (34') resetting the memory circuit (36) to arbitrarily disabling said enabling gate (16) in order to arbitrarily stop the energisation of the electromagnet (20).

4. The metering pump according to the preceeding claims, characterized in that said piston position detector (12) has a hysteresis cycle large enough to allow a safe and careful switching between a high logical state and a low logical state of said position detector (12) at some piston positions.

5. The metering pump according to claim 4, characterized in that said piston detector (12) is a Hall effect position detector.

6. The metering pump according to preceeding claims characterized in that the power amplifier (18) for energizing said electromagnet (20), supplied by a network a.c. voltage, contains a silicon controlled rectifier (SCR), said enabling gate (16) receiving in addition to said signal coming from the piston position detector (12), a signal (17b) of zero crossing of the a.c. network voltage and a true enabling signal (17a) coming from a circuit (90) receiving a piston position signal (14b), a plurality of electromagnet energisation starting signal plurality (38a-38n; 38') a numerical signal (30) automatically presetting the liquid metered volume for stopping the electromagnet energisation at the preset volume and a possible signal (34') for arbitrarily stopping the energisation of said electromagnet.

6. The metering pump according to claim 1, characterized in that a memory (126), controlling the starting and stopping of the electromagnet (20) has just one setting input (127) obtained by combining through a logical function, such as a logical OR function (140), a setting input (137a-137b) of different metered volumes and a setting input (128) for arbitrary metered volume and two resetting in-

puts, one connected to the different metered volumes and one (128) to the arbitrary metered volume.

7. The metering pump according to claim 6, characterized in that the resetting input of the different volumes comprises as many step function generators 20 as one the metered volumes to be present and a voltage comparator circuit (124) comparing the voltage of the step function with one or more reference voltages, such a voltage comparator (124) emitting a resetting signal for the memory (126) when said step function equals one of said reference voltages, operating as a counter and signaller of preset piston strokes.

8. The metering pump according to caim 7, characterized in that said resetting input for the different volumes comprises as many step function generators, as the metered volumes to be preset, said step function generators each producing steps of different heights, a voltage comparator circuit (124) comparing the voltage of the step signal with a preset reference voltage ($+V_R$), said comparator emitting a reset signal for the memory (126) when said step function equals said reference voltage.

9. The metering pump according to claim 8, characterized in that the step function generators are formed by a generator (110) of pulses having rigorously equal time length , derived from a piston detector, charging a capacitor (122) through a resistor plurality (120a-120d) connectable through switching means (118) so that, by changing the time constant of said circuit comprising said capacitor (122) and one of said resistor (120a-120d), being however said time constant much longer than the length of said pulses, the height of the single voltage steps is changed, reaching the reference voltage ($+V_R$)) with a higher pulse number for lower step heights in order to carry out the consisting of preset pulse numbers.

10. The metering pump according to claims 6 or 7, characterized in that said resetting input for the different metered volumes comprise just one step function generator, having fixed step height on a voltage comparator circuit (124) comparing said step function with one of a number of reference voltages (V_{R1}-V_{R4}) as the metered volumes to be preset, said comparator emitting a reset signal for the memory (126) when said step function equals one of said reference voltages (V_{R1}-V_{R4}).

11. The metering pump according to claim 10, characterized in that the step function generator comprises a generator of pulses (110) having rigorously equal time length charging a capacitor (122) through a resistor (120), with which said capacitor (122) forms a time constant much longer than the time length of said pulses, so that each pulse forms a fixed voltage steps and, depending on to the reference voltage (V_{R1}--V_{R4}) selected through switching means (118), the necessary pulse number to reach said reference voltage (V_{R1}-V_{R4}) is changed.

12. The metering pump, according to claims 6 to 11, characterized in that the use of the setting input (138) for arbitrary metered volumes interrputs the step function generation so that the resetting can be carried out just through the input (128) or arbirarily metered volume resetting.

13. The metering pump, according to claim 12, characterized in that, the interruption of the step signal generation is obtained by deactuating all the switching means (118) connecting the resistor plurality (120-120d) with the capacitor (122) in order to prevent the words equal time lenght pulses to charge said capacitor (122).

14. The metering pump, according to claim 12, characterized in that the interruption of the step function generation is obtained by short circuiting said capacitor (12) in order not to be charged by said equal line length pulses and deactuating all the switching means (118) chossing the reference voltage, in order to impose on the voltage comparator (124) a not .... reference voltage to avoid that said voltage comparator (124) resets said memory (126).

15. The metering pump, according to claims 6 to 11, characterized in that said switching means (118) for the step function generator are controlled by memory means (13a) settable on separated inputs (136a-136d) in a number equal to the number of metered volumes to the chosen and resettable at the end of every metering when is reset said memory (126) actuating the energisation of said electromagnet.

16. The metering pump, according to caim 15, characterized in that the memory measn (134) control switching means (118) connecting on choose a resistor plurality (120a-120d) to a capacitor (122) to make a step function generator having settable step height.

17. The metering pump, according to claim 15, characterized in that the memory means (134) control the switching means (118) connecting on choose a reference voltage plurality (V_{R1}-V_{R4}) to said voltage comparator (124).

18. The metering pump, according to claims 6 to 11, characterized in that tor ecue the control connection number both to the memory (126) controlling the electromagnet (20) energisation starting and stopping and the memory (134) controlling the swtiching means (118) of the semplified counter, containing step function generator is used a voltage divider comprised by four resistor respectively series connected between the supply voltage and ground, the two external resistor of said series having substantially double resistance with respect to that of the two internal resistors, the junction

between the first and second resistor fing connected to a first input and the junction between the third and the fourth resistor being connected to a second input and the junction between the second and third resistor or control junction of the voltage divided is connected to a control terminal switcheable either the supply voltage or to the ground voltage for producing respective high or low logical states for said first and second input.

19. The metering pump, according to claims 5, characterized in that the pump electromagnet (20) during which is carried out by a silicon controlled rectifier (SCR) (94) uses an elablizing gate (16) connected through an optical path (149) to said hall effectpiston position detector (12) and a zero crossing elector (92) for the network voltage applied to the electromagnet (20) in order to syncronize the pump movement with said network voltage.

20. Metering pump or vibrating ,kind comprising a piston actuated by a movable core moved by an electromagnet (20), a piston position detector (12), an evabling gate (16) between said piston position detector (12) and a power aplifier (18) driving said electromagnet (20) a microprocessor (290) control coming out all the functions of presetting and counting the desired metered liquid volumes to be supplied by the pump, characterized in that said, microprocess (290) comprises at least an input/output (I/O) port (292) , a read only memory (ROM-, (294), a randow access memory (RAM) (296), an address bus (298) a date transfer bus (299) a central processing unit (CPU) (300), a clock (302)possibly quartz (304) stabilized and input and output connection from and to peripheral units (306,308).

21. Metering pump, according to claim 20, characterized in that the microprocessor operating rending through the inputs connections of the I/O port (292) to the control processing unit (CPU) (300) the directions reagarding a metered liquid volume to be supplied by the received by the I/O port (292) providing to extract from the ROM (294) the information regarding preset metered volumes, said information being presented to the RAM (296) for extracting therefrom numerical volumes pump stroke numbers to be presented to the central unit (300) such that at the end of the phase determining the mass stroke number, the central unit (300) forwards to the I/O port (292) directions for enabling a gate (16) allowing to energize an electromagnet (20).

22. Metering pump, according to claim 21, wherein the electromagnet (20) energisation controls a pump piston position delected by a elector (12) which in turn controls said electromagnet (20) energisation, establishing oscillations allowing said liquid pumping, so that when said oscillations have been established, arriveto the I/O port (292) pulses corresponding to said oscillations, which are counted in the central processing unit (300) and their total number is compared with the number recorded in the RAM (296), corresponding to the desired liquid volume, so that, when the pulse number totalized in the central unit coincides with the number recorded in the RAM (296) the control unit (300) emits a stopping direction to the I/O port (292), which provided to stop the electromagnet energisation (20) and thus the pump acutation possibly indicating through dipolysi the supply of a desired liquid metered volume.

Fig.1

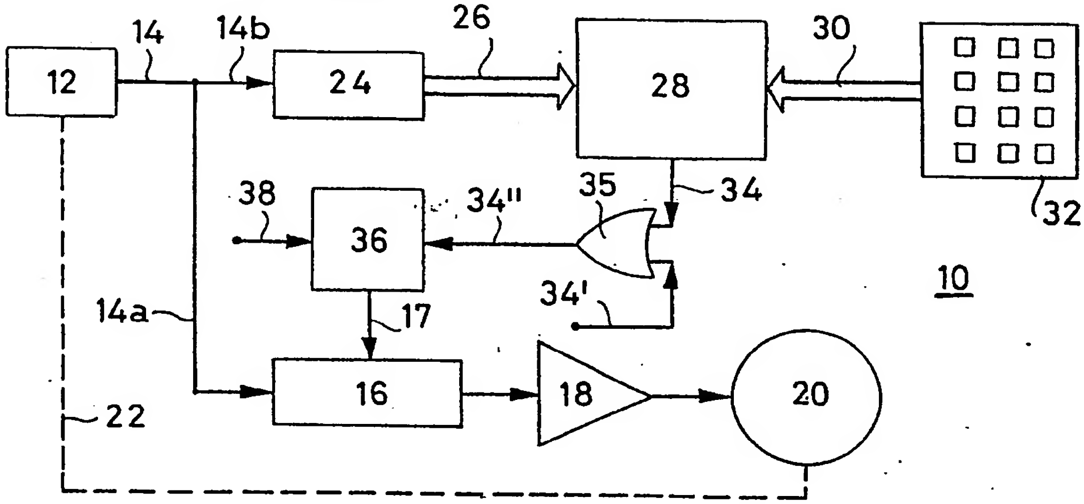

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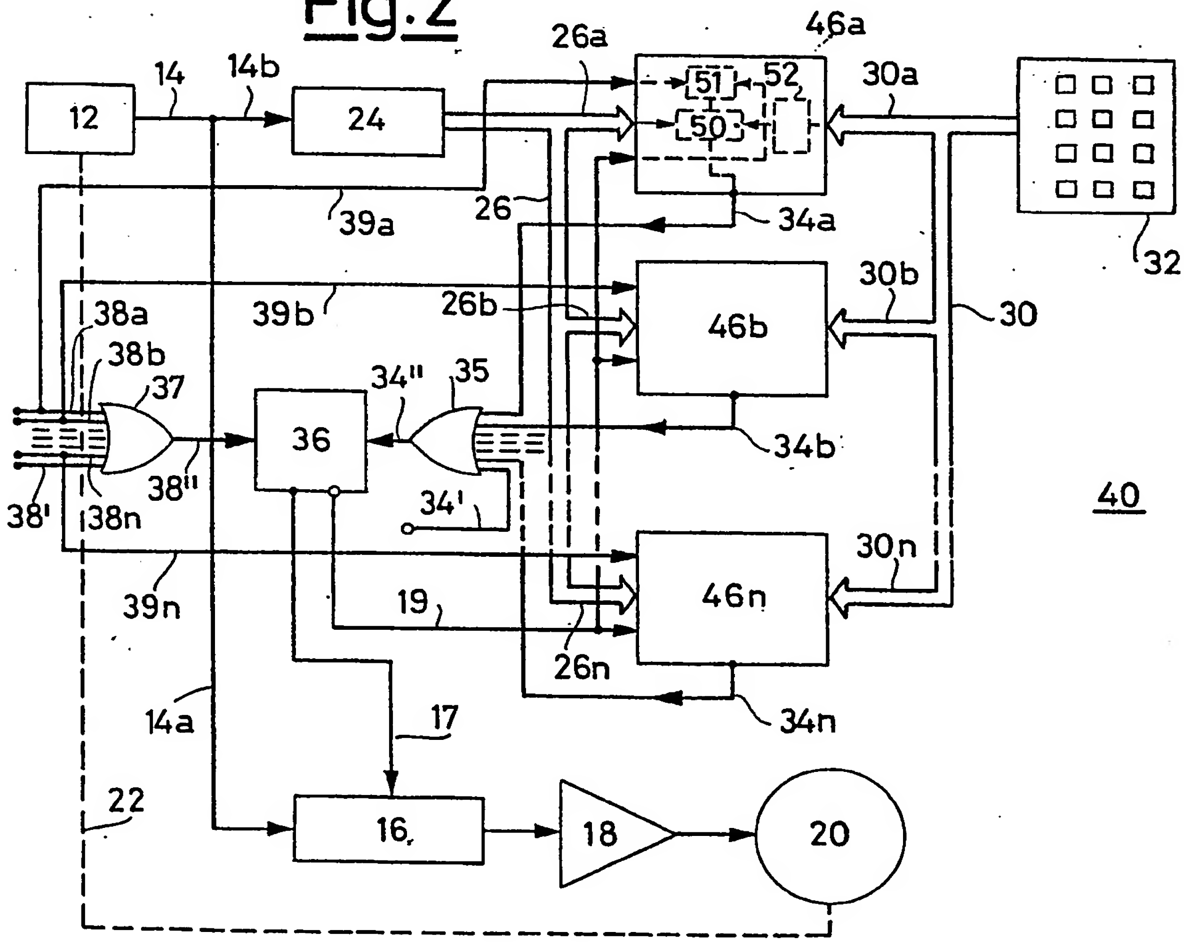
Fig.2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14b
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52
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30a
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39a
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34a
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26b
30b
46b
30
38b
37
34''
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38'
38''
34b
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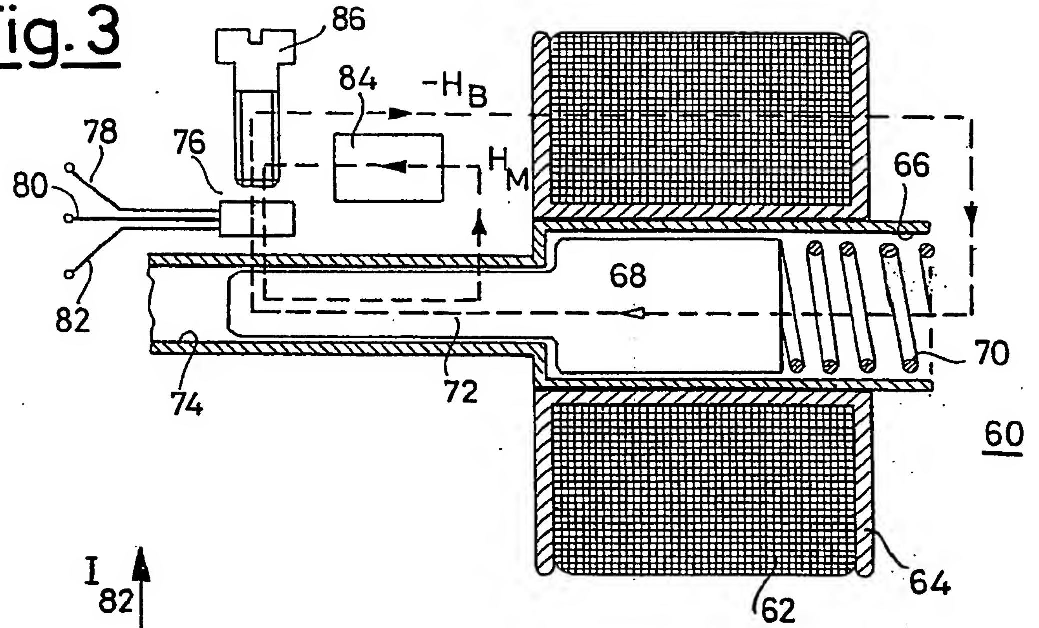
20

Fig.3



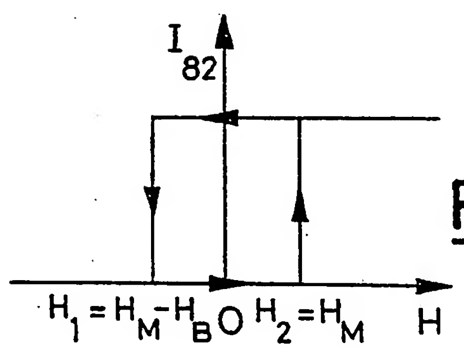


Fig.4

Fig.5

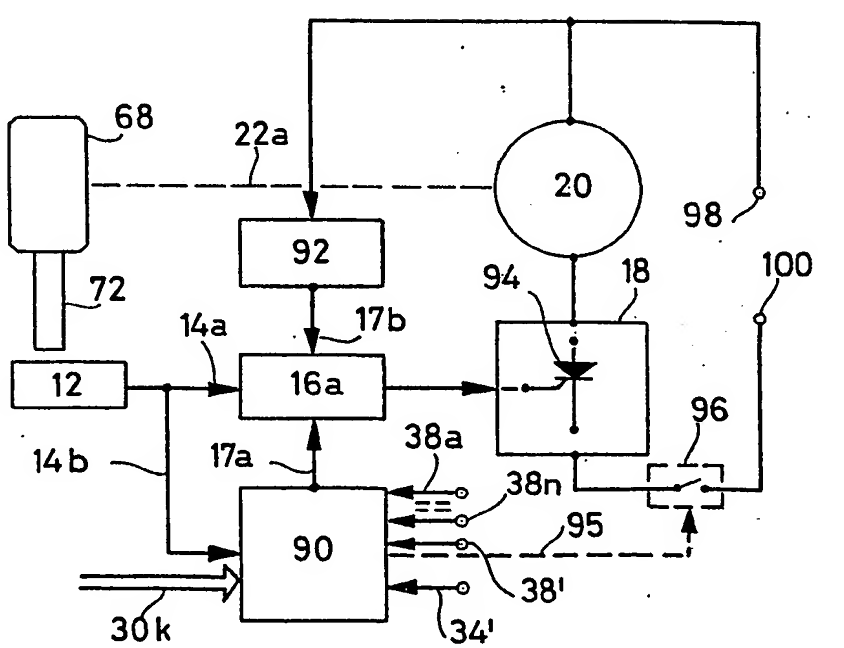


Fig. 6

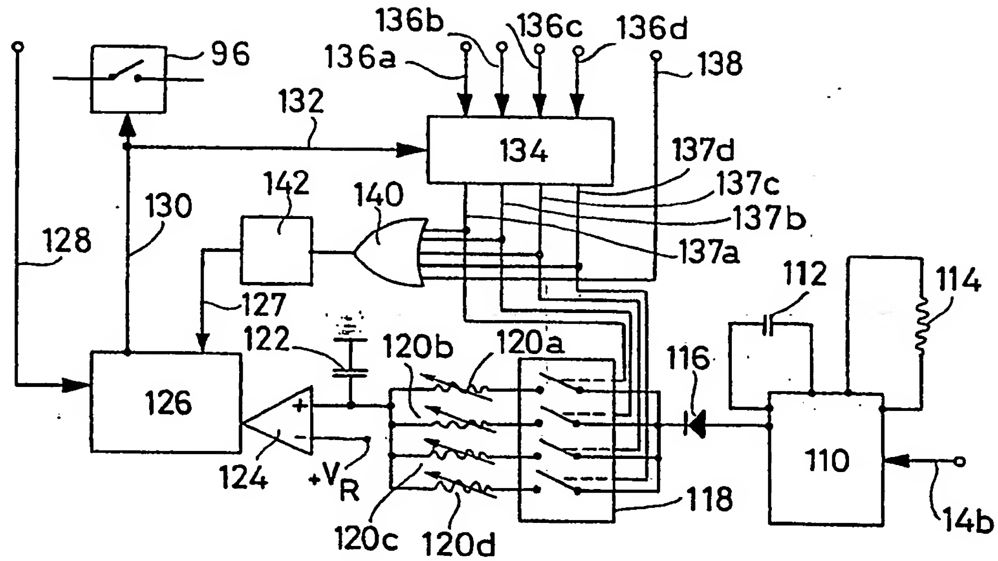


Fig. 7

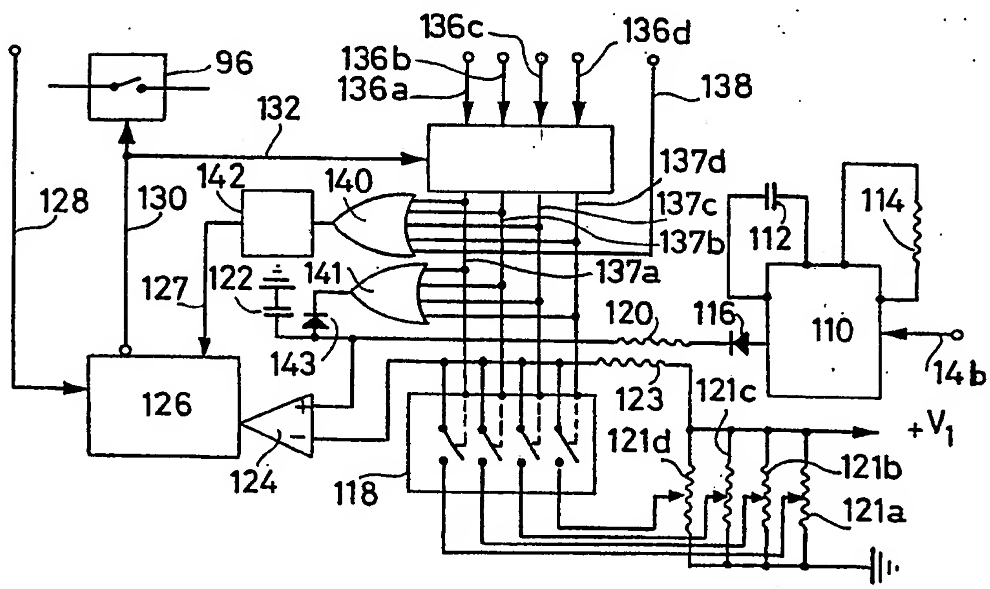
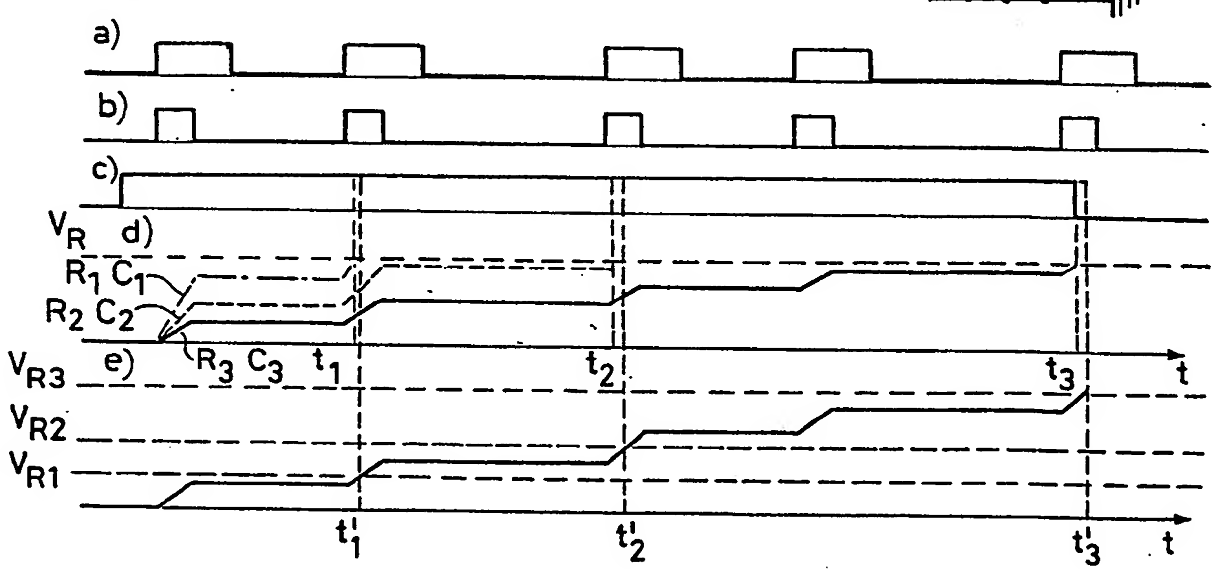
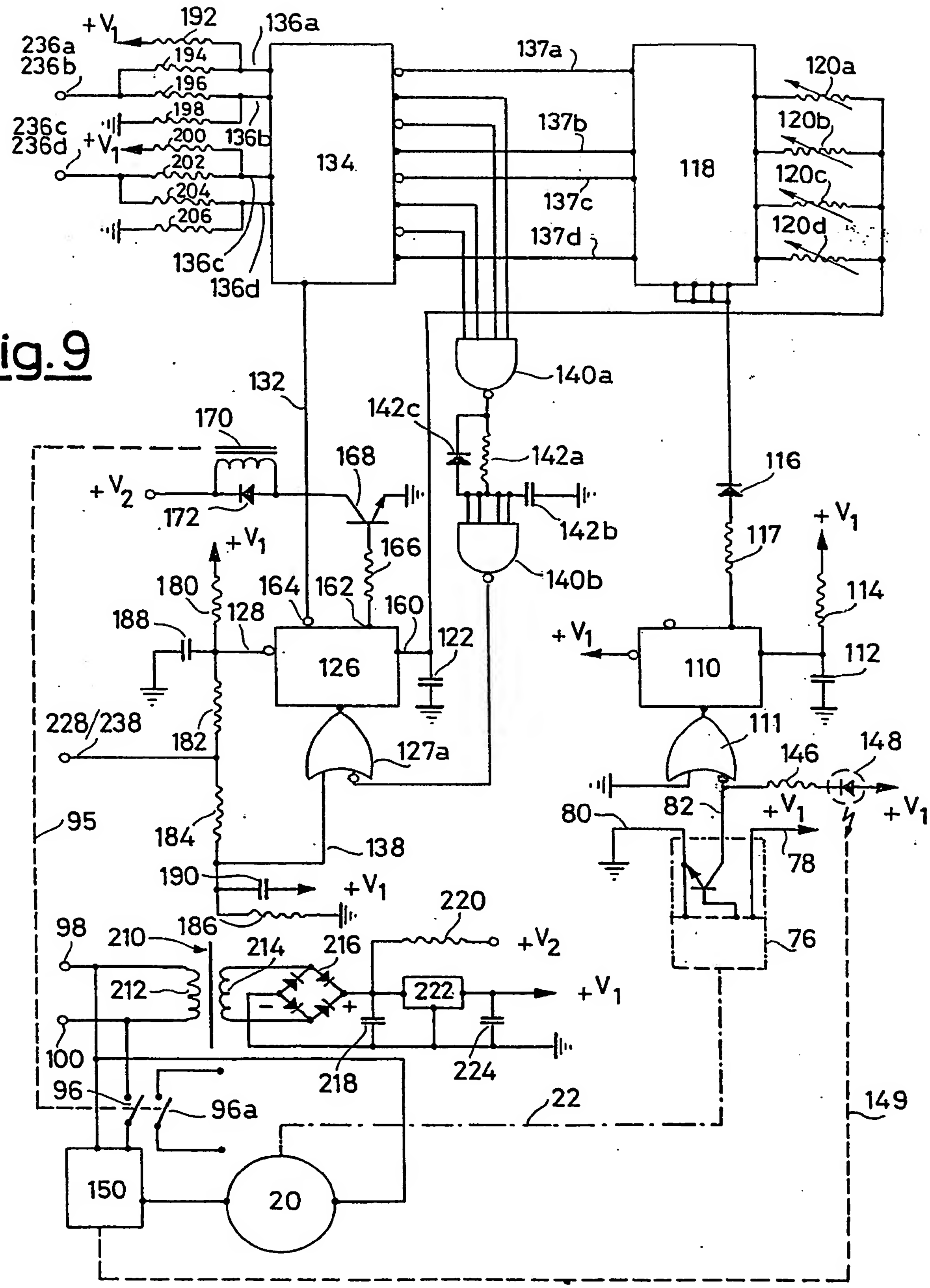


Fig. 8





+V1
192
136a
236a
236b
194
196
198
136b
236c
236d
+V1
200
202
204
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136c
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134
137a
137b
137c
137d
118
120a
120b
120c
120d
140a
132
142c
142a
170
168
116
+V2
172
142b
+V1
166
117
+V1
180
164
162
140b
114
128
160
188
122
+V1
126
110
112
111
228/238
182
127a
146
148
80
82
+V1
+V1
95
184
138
78
190
+V1
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Fig. 9

Fig.11

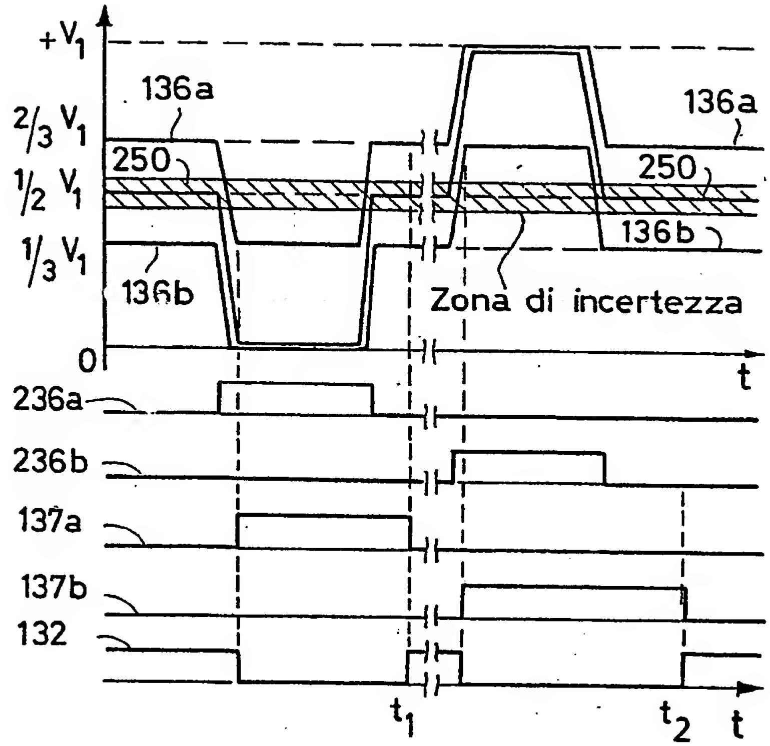


Fig.10

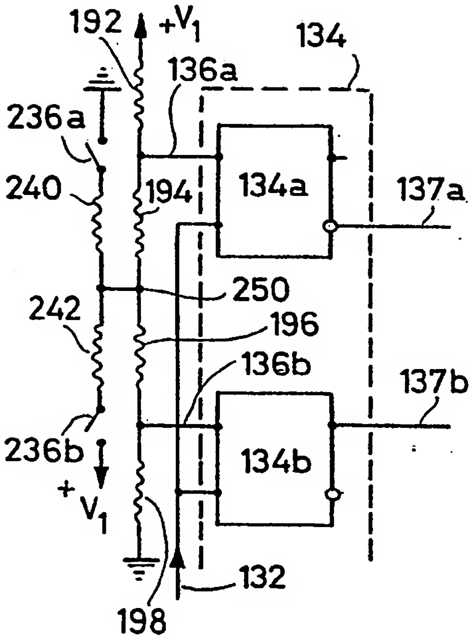


Fig.12

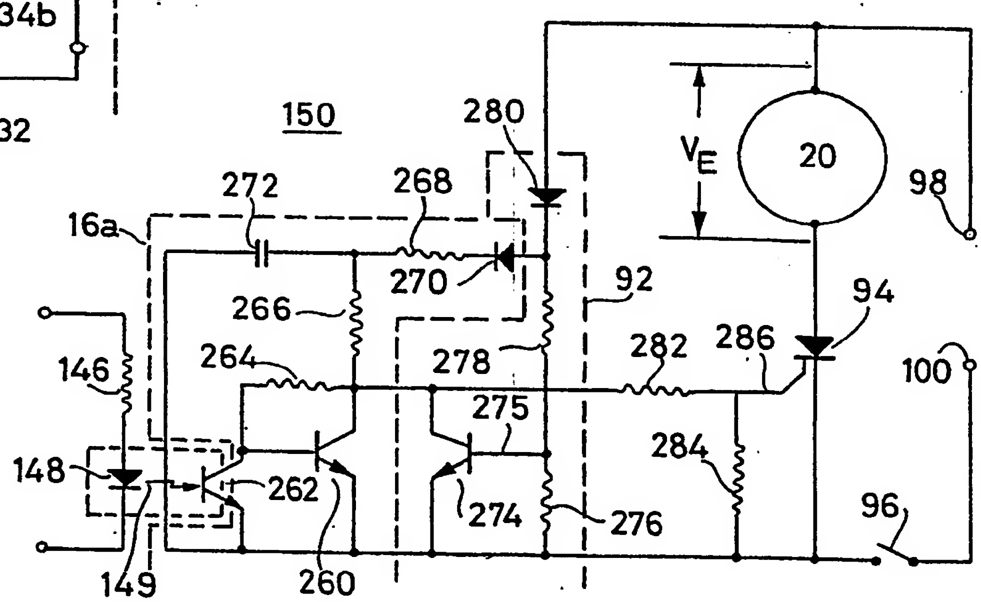
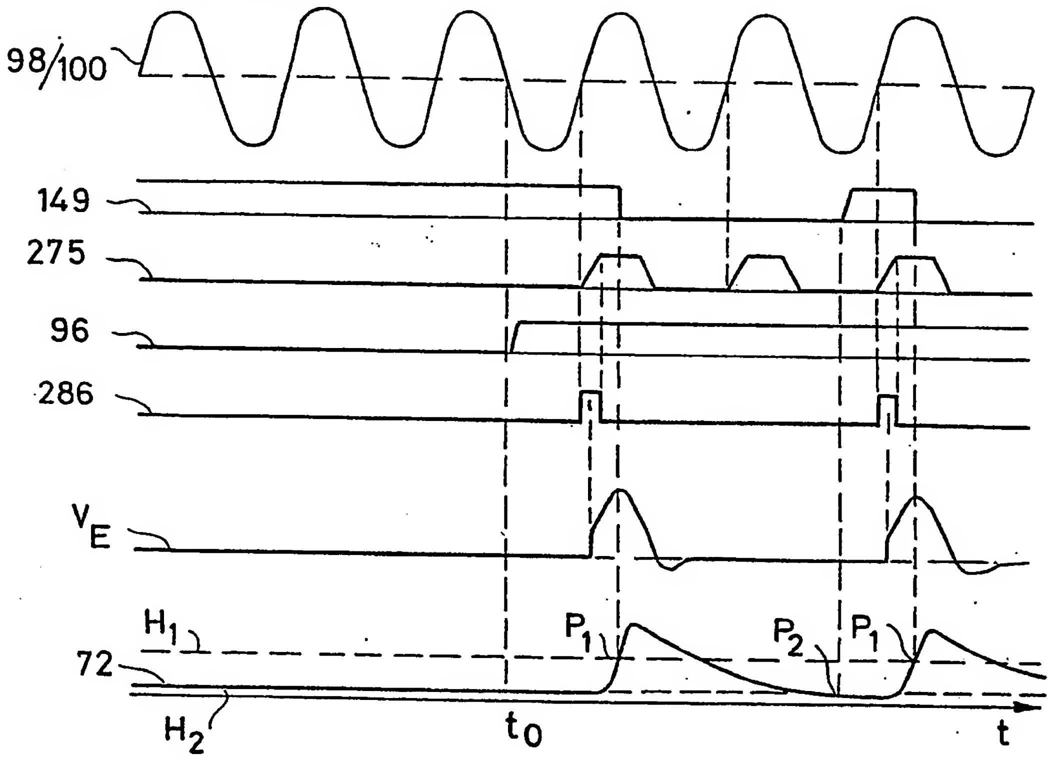


Fig.13



98/100
149
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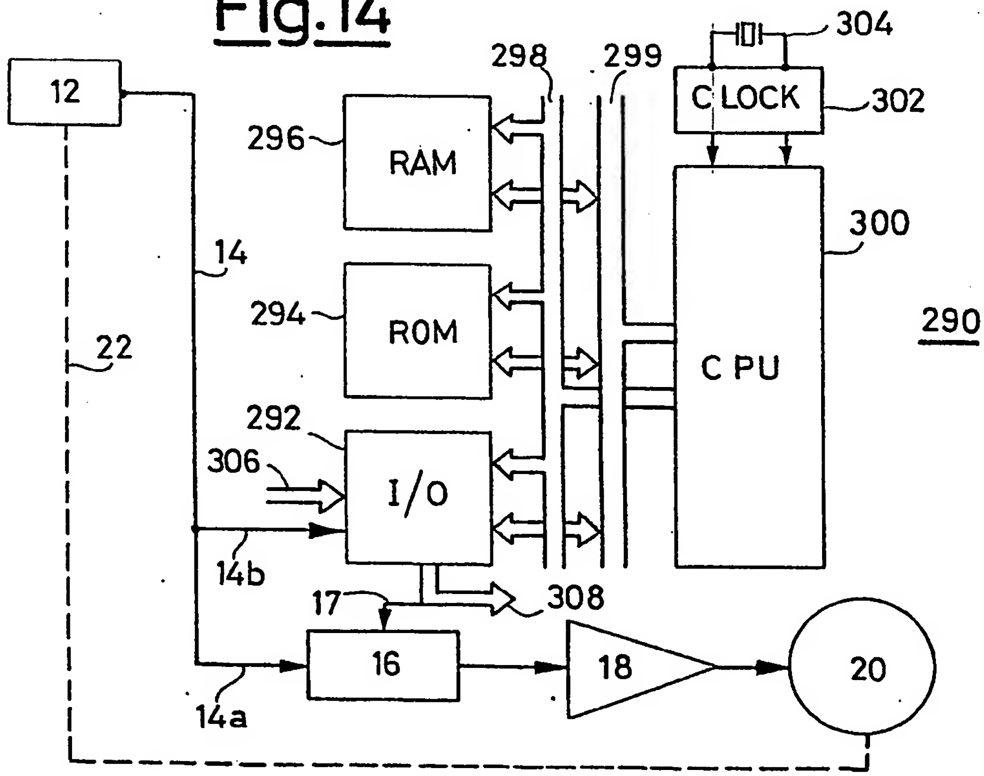
Fig.14



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CLOCK
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300
CPU
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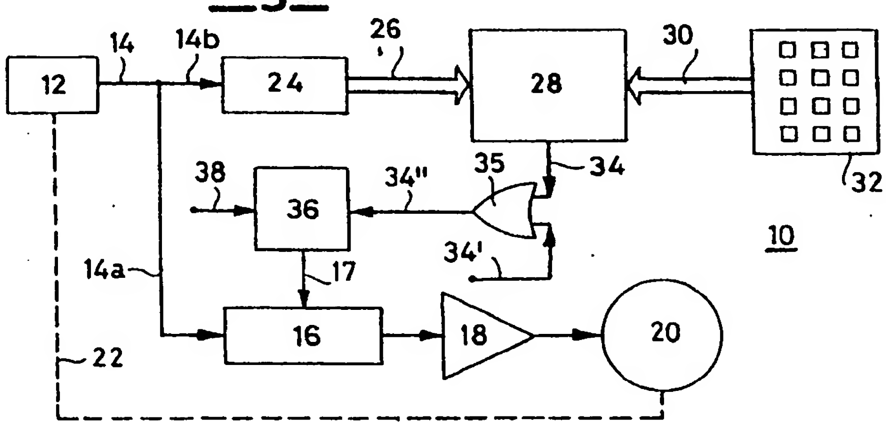
(54) System and device for having desired liquid volumes supplied by a metering pump in variable flow rate condition.

(57) In a metering vibrating pump in variable flow rate condition a system and a device for having desired liquid quantities supplied comprising a memory circuit (36) set a supply beginning signal (38), a counter (24) counting a certain pump stroke number detected by a detector (12) of piston position in said pump, a numerical comparator (28) comparing the numbers emitted by the counter (24) with preset numbers formed by a numerical combinator (32) for outputting a reset signal for said memory circuit (36), said memory circuit (36) starting the pumping operation when it is set and stopping said operation when it is reset.

Fig.1



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EUROPEAN SEARCH REPORT

Application Number

EP 88 20 0585

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 105 138 (LEHMANN) * Whole document * - - -	1,3,6	B 67 D 5/30 G 01 F 15/00 G 01 F 11/04 F 04 B 49/06 F 04 B 51/00
A	US-A-3 773 219 (IRIE et al.) * Column 3, line 22 - column 6, line 24; figures 1-3,5 * - - -	1,2	
A	US-A-4 433 795 (MAIEFSKI et al.) * Column 18, line 54 - column 19, line 47; figures 1-3,12-15 * - - -	1,2,20-22	
A	US-A-3 756 456 (GEORGI) * Column 8, line 36 - column 9, line 61; figures 1-4 * - - - - -	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 01 F
B 67 D
F 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	10 April 91	ROSE A.R.P.

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